TYL 2: Aphelion

Electrical & Mechanical Engineering

Experimental Apparatus for Acoustics' Measurement and Characterization in HVAC Design

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Abstract

The purpose of this project was to design and build an experimental apparatus capable of generating sound waves with desired properties and allowing the acquisition of data in order to assess noise reduction devices in HVAC ducting systems.

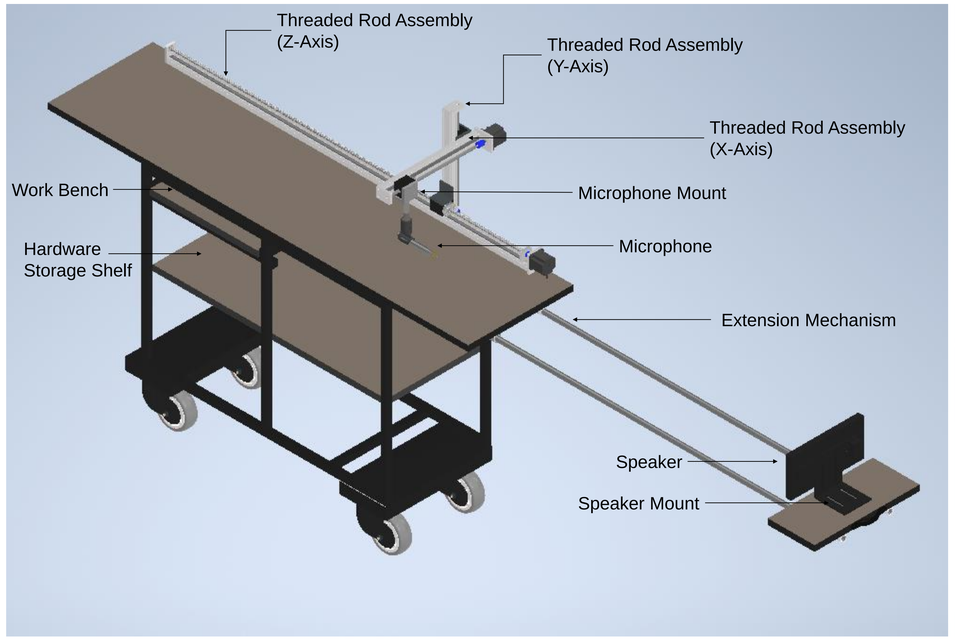
Background

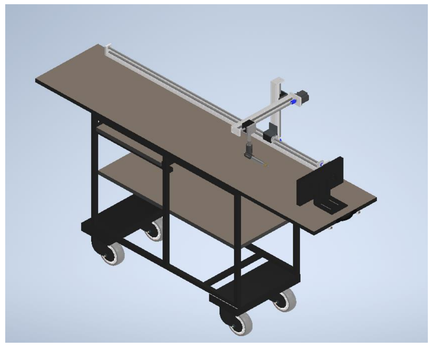
- In an HVAC system, air is distributed by fans and ducts in order to meet thermal energy demands. The fan and the air velocity in the ducts transmit and generate noise.
- The noise transmitted and created in HVAC ducting needs to be controlled in order to maximize the occupants' comfort. In this sense, research on metamaterials to reduce noise can be implemented in duct systems.
- Providing an apparatus which allows for measuring noise reduction at a point, in a plane, and within a cube will lead to reduced future costs in material, space, and energy.

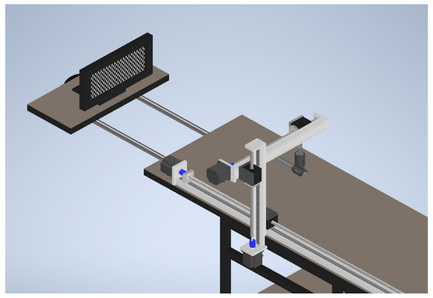
Specifications

Functions	Value	Implementation	Measurement	Reasons
Control sound wave properties.	SPL of 90 dBA, Frequency of 300-16k Hz.	Sound generated through LabVIEW and transferred to speaker.	NI-DAQmx to receive voltage signal from the microphone.	To test the sound characteristics up to OSHA permissible exposure limits (PEL), capability of human ear as per National Institute of Health.
Measure sound characteristics.	90dB, 300-8k Hz.	Microphone with the ability to measure the sound characteristics.	NI-DAQmx to receive voltage signal from the microphone.	Compare the difference between original and filtered sound characteristics.
3D Movement for the Microphone.	Movement of 354.08 mm in the X-axis; 309.1 mm in the Y-axis; 1474.6 mm in the Z-axis.	Movement arms run by programmable stepper motors.	Preset path is calibrated based on a time-domain, open control loop to collect data at preset points.	Mapping the sound characteristics after passing through the metamaterial.

Experimental Apparatus







Control Process

- The apparatus is designed to collect the sound profile at a point (1D), in a plane (2D), or within a cube (3D) by generating a signal from the plane wave speaker, moving the microphone to the exact desired placement, and recording the sound profile at that location.
- The directional speaker allows the sound waves to propagate with controllable boundary conditions.
- The 1D logic allows the user to input the exact coordinates for X, Y, and Z, the 2D logic allows the user to input values for ΔX, Δ Y, and Z, and the 3D logic allows the user to input values for ΔX, ΔY, and ΔZ.
- The placement of the microphone is controlled by three threaded rod assemblies and three stepper motors which move the assembly with a resolution of 1/2 mm.
- The omnidirectional microphone receives the sound in the same manner as the human ear. This data is recorded and stored for analysis.